ERDC/CERL TR-14-32

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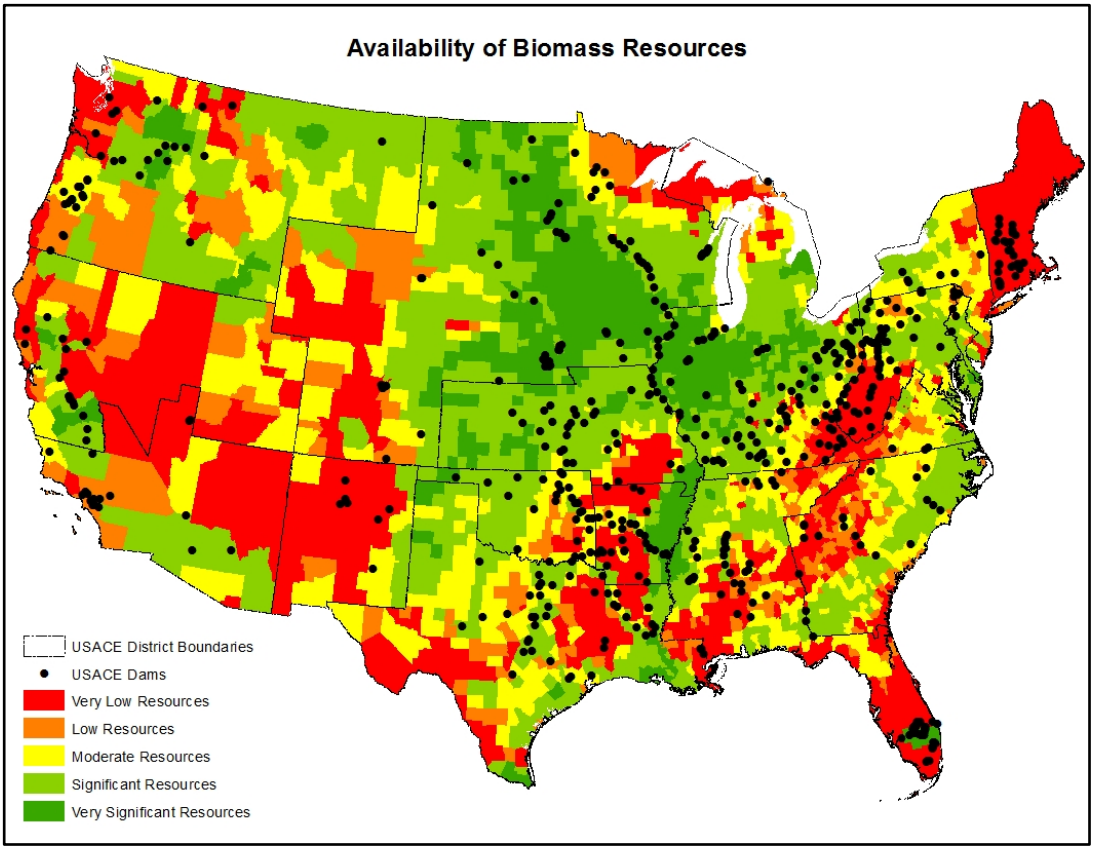
USACE Institute of Water Resources Global Change Sustainability Program

Biofuel Production

Considerations for USACE Civil Works Business Lines

Natalie R. Myers, Dick L. Gebhart, and Matthew D. Hiett

December 2014



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Natalie R. Myers and Dick L. Gebhart

Construction Engineering Research Laboratory (CERL)
U.S. Army Engineer Research and Development Center (ERDC)
2902 Newmark Drive
PO Box 9005
Champaign, IL 61826-9005

Matthew D. Hiett

Oak Ridge Associated Universities (ORAU)
Oak Ridge Institute for Science and Education (ORISE)
2902 Newmark Drive
PO Box 9005
Champaign, IL 61826-9005

Prepared for U.S. Army Corps of Engineers
Institute for Water Resources
7701 Telegraph Rd
Alexandria, VA 22315

Under P2 Project #403280, "Technical Support for Institute of Water Resources (USACE) Global Change Sustainability Program"

Abstract

The 2007 Energy Independence and Security Act (EISA) has set goals for renewable fuels standards (RFS) that include the production of 36 billion gallons of biofuels by 2022, with 21 billion gallons from non-corn sources. To meet the congressionally mandated bioenergy goals, the evolving bioenergy industry in the United States must be efficient, reliable, and sustainable. To that end, industry leaders are encouraging stakeholder engagement. Because it manages large areas of land, the U.S. Army is gaining national appeal for providing cellulosic feedstock to an emerging biofuels industry. Although not currently engaged, the Army and its directorates are investigating how biofuel production might impact the future viability of their mission and operations. The indicator framework presented in this document characterizes regional aspects of biofuel production, which is intended to provide a heightened awareness of how biofuel production might address various long-term issues and threats to mission sustainment.

Contents

Figures and Tables

Figures

Tables

Preface

This study was conducted for the U.S. Army Corps of Engineers Institute for Water Resources (IWR) under P2 Project # 403280, "Technical Support for Institute of Water Resources (USACE) Global Change Sustainability Program." The technical monitor was Dr. Kathleen D. White (IWR, USACE).

The work was performed by the Ecological Processes Branch (CN-N) of the Installation Division (CN), U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Mr. William D. Meyer was Chief, CEERD-CNN; Ms. Michelle Hanson was Chief, CEERD-CN; and Mr. Alan Anderson (CEERD-CVT) was the Technical Director for Military Ranges and Lands. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Dr. Ilker Adiguzel.

It is acknowledged that this research was supported in part by an appointment to the Postgraduate Research Participation Program at ERDC-CERL that is administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the U.S. Department of Energy and ERDC-CERL.

COL Jeffrey R. Eckstein was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

1 Introduction

1.1 Background

A group of environmental specialists at the Engineer Research and Development Center–Construction Engineer Research Laboratory (ERDC-CERL) have developed and subsequently enhanced the Sustainable Installation Regional Resource Assessment (SIRRA) as a process for characterizing military land regions based on a set of indicators which are then grouped into a range of issues that may affect military installations and their locality. The nation and the U.S. Army have a need to review the potential for feedstock-based biofuel production to meet national biofuel energy mandates.

1.2 Objective

This current report outlines work done to support development of a SIRRA Biofuel Application. By using the SIRRA approach, the Biofuel Application can be used to characterize regions within the United States, The application is to be based on a set of indicators relevant to biofuel production as outlined here. The application also facilitates informed decision making by providing a means to synthesize, analyze, and visualize vast amounts of information in a spatially integrated manner.

1.3 Approach

The technical approach taken for this effort is summarized within the remaining chapters. Chapter 2 presents the driver of this study and defines the applicability of applying the SIRRA approach. Based on literature review and stakeholder engagement, Chapter 3 examines biofuel production in relation to the eight U.S. Army Corps of Engineers, Civil Works directorate (USACE-CW) business lines. Chapter 3 includes the identification of potential connections and the indicators that illuminate those connections. Discussion in this chapter is intended to spur creative thinking about the biofuels industry and potential links between USACE-CW business lines. Chapter 4 concludes with a SIRRA Biofuel Application framework of indicators, and the recommended steps to implementing the framework.

1.4 Scope

The scope of this effort covers the interplay between biofuel production and USACE-CW business lines. Biofuel production in this context includes biofuel feedstock production or acquisition, transportation networks for feedstock and biofuel, and processing of feedstocks at biofuel production facilities. Indicators are identified that capture the combined interaction of these activities. With appropriate development, the indicators are intended to provide the baseline information about the region and illuminate key issues which may be current or future threats or opportunities for biofuel production.

2 Background

2.1 Considering biofuel production

The 2007 Energy Independence and Security Act (EISA)[1] set national Renewable Fuels Standards (RFS) with goals that include the production of 36 billion gallons of biofuels by 2022, of which 21 billion gallons are to be produced from non-corn sources. Thus, the RFS is likely to play a dominant role in the development of the U.S. biofuels sector over the long term. Yet, questions still exist about the ability of the U.S. biofuels industry to meet the expanding mandate for biofuels from cellulosic materials. Questions stem from the slow development to date of production capacity from cellulosic materials and from biomass-based biodiesel that remains expensive to produce due to relatively high prices for its feedstocks. Additionally, considerable uncertainty remains regarding development of the infrastructure capacity needed to deliver the expanding biofuels mandate to consumers (e.g. trucks, pipelines, pumps).

The U.S. Environmental Protection Agency (EPA) is responsible for revising and implementing regulations to ensure that the RFS are met. To accomplish this task, EPA calculates annual percentage standards for biofuel production and applies them to refiners, blenders, and importers of gasoline and diesel fuels. In other words, the EPA determines each individual company's renewable volume obligation (RVO). To facilitate meeting the requirements while taking into consideration regional differences in biofuels production and availability, EPA established a system of tradable RVOs. As a result, the commercial sector is motivated to identify potential feedstock sources. Because it manages large areas of land, the U.S. Army is gaining national appeal for providing cellulosic feedstock to an emerging biofuels industry. Currently, the Army has not engaged in biofuel production because it recognizes the numerous uncertainties associated with net energy and environmental benefits. However, it is not inconceivable that future economic conditions and/or energy policies will motivate the Army toward engagement; thus, it behooves the Army to consider the potential issues now.

[1] Public Law 110-140 (2007), signed 19 December 19, 2007 by President George W. Bush.

The cultivation of feedstocks for fuel does not come without some risk of negative environmental impact, namely in terms of soil resources, water quality and water use, biodiversity, and ecosystem services (Gollany et al. 2011). It is important to note that not all Army lands can be reasonably expected to economically produce cellulosic feedstock.

In its sustainability plan, USACE-CW has identified or referenced sustainability strategies as part of its goals to reduce energy, petroleum, and water consumption, and greenhouse gas (GHG) emissions. One of these potential sustainability strategies is biofuel production. This work provides additional analysis that is needed to understand how biofuel production might impact USACE business lines and operations. Considerations for that analysis result from the tasks outlined below.

- Identification of viable feedstocks from USACE-CW operations by land use, activity, or business line.
- Quantification of the positive and negative production impacts along USACE-CW business lines.
- Quantification of the potential total USACE-CW feedstock supply.
- Identification of USACE-CW sites that offer distinct economic and infrastructure benefits to the biofuels sector.

It is also important to note that there is no single feedstock type or land-use management practice that will work for every potential cellulosic biofuel location and further, the choice of an ideal cellulosic biofuel crop system will always be location- and market-specific (Dale et al. 2010).

2.2 The Sustainable Installation Regional Resource Assessment approach

As outlined previously, SIRRA is a process for characterizing land regions that is based on a set of indicators which are grouped into a range of issues that may affect military installations and their locality. The determined indicator(s) may be used to express the relative ranking of installations or facilities based on single measures (or groups of measures) that define an issue. This standardized approach enables the use of national-level data to evaluate the regional aspects of the installation setting. This approach provides a heightened awareness of long-term issues that could threaten mission sustainment. The approach also allows an evaluator the choice to determine whether an issue or group of indicators is germane to the

question at hand concerning a range or installation's future viability. (Jenicek et al. 2004)

The SIRRA methodology has been documented in a series of ERDC-CERL reports. SIRRA was first developed and presented in ERDC/CERL TR-02-27, *An Assessment of Encroachment Mitigation Techniques for Army Lands* (Deal et al. 2002), and it was further developed in ERDC/CERL SR-02-12, *Sustainable Installation Risk Assessment and Stationing Implications* (Fournier et al. 2002). SIRRA Version 1 was documented in ERDC/CERL TR-04-9, *The Sustainable Installations Regional Resource Assessment (SIRRA) Capability: Version 1* (Jenicek et al. 2004). An enhanced SIRRA Version 2 is currently available online as a web-based analysis tool.[2]

2.2.1 Indicator framework

An "indicator" is a piece of information that reflects what is happening in a larger system. It allows observers to see the big picture by looking at a smaller part of it. Indicators are often quantitative measures such as physical or economic data. For example, traditional indicators such as inflation and unemployment rates are used for making economic decisions. Indicators are widely used as a tool for monitoring progress and to simplify, quantify, and communicate complex issues. Multiple indicators are sometimes aggregated into an index, usually for comparison across locations or to indicate change over time. Indicators are often used as the feedback mechanism to inform policy changes intended to improve the situation being measured. Indicators used in the SIRRA analysis cycle provide baseline information about the region and illuminate key issues which may be a current or future threat to mission sustainment, mission realignments, or regional environmental health. These indicators provide the starting point for regional planning and impact amelioration.

Similarly, the goal of the SIRRA Biofuel Application indicator set is to provide the baseline information about the region and to illuminate key issues which may be a current or future threat or opportunity for biofuel production. The target audience consists of USACE business line

[2] http://datacenter.leamgroup.com/sirra/; (note that the LEAM group only provides the framework for the online tool.) The SIRRA web-interface allows the user to begin mapping quick and simple illustrations of critical issues surrounding military installations. SIRRA maps visually communicate to the public, officials, and installation managers those areas in need of further study and attention to the management of local resources.

managers and facility managers. Indicator and analysis frameworks must be compatible with existing analysis frameworks (e.g., CorpsMap), and the frameworks often rely on existing national datasets (i.e., those managed and collected by national organizations). Table 1 presents a sample and specific example of indicators and datasets.

Table 1. Generic regional resource assessment framework followed by specific example for threatened and endangered species (TES).

Issue		
	Indicator	Data Source
	Indicator	Data Source
	Indicator	Data Source
Threatened and Endangered Species		
	# of TES in state	Fish and Wildlife Service
	Species at Risk	Jnl of Amer Wtr Resources Assoc
	Federally listed TES by Ecoregion	NatureServe
	TES of Concern	NatureServe

2.2.2 Analysis concept and results

SIRRA data is derived from validated national sources, compiled in a consistent format, and covers a wide array of sustainability topics. SIRRA quantifies the state or condition of indicators by providing sustainability ratings for single indicators. However, it does not currently provide a sustainability rating based on an index (i.e., a group of indicators). The SIRRA sustainment ratings contained in Version 1, categorize indicator measures in three classes of ratings as follows: sustainable, moderately sustainable, or unsustainable. The current SIRRA sustainability ratings in Version 2 were adjusted to provide a finer resolution that highlights differences between a large number of installations and facilities within various regional settings. These five sustainability ratings are available on the SIRRA website and also presented below.

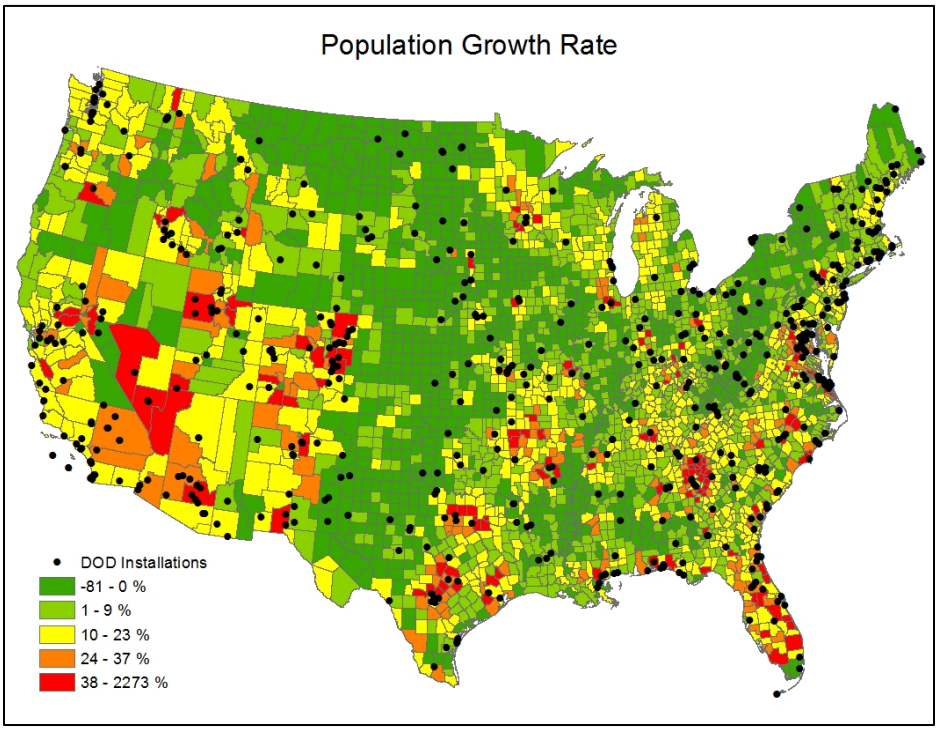
- Very low vulnerability
- Low vulnerability
- Moderate vulnerability
- Vulnerable
- High vulnerability

The process of setting the thresholds for the categories (where they are not already set by data providers or regulation) is to perform a statistical analysis of the dataset. Often a normal distribution is used to divide the five sustainability categories. It is important to note that: (1) the ratings are related to the originating data from the counties and watershed—not the military installations themselves; and (2) the identification of specific risk thresholds and classifications is subjective in some cases, and alternative classifications are possible. The database's goal is to provide useful insight into identifying relative ratings for resource issues across installations, but these results should not be interpreted as absolute.

The data is then mapped into geographic information system (GIS) coverages for individual indicators coded by sustainability vulnerability. Military installations are placed geographically in a location and the GIS data is applied to evaluate regional aspects of the installation setting. Figure 1 depicts the results of this mapping for the SIRRA population growth rate indicator. As an example, the orange sustainment rating for San Bernardino County (in southern California) is shown in Figure 1 and indicates that installations located within or near this county are vulnerable to sustainment issues due to regional population growth rates.

Figure 1. Map depicting the SIRRA population growth rate indicator.

NOTE: Sustainment ratings are color coded as: very low vulnerability (green), low vulnerability (light green), moderate vulnerability (yellow), vulnerable (orange), and high vulnerability (red).



Collectively, indicators can help to identify potential issues that should be considered whenever stationing, base realignment, and mission sustainment decisions are made. This information can also inform installation sustainability planning. Some limitations of this study do necessitate caution in the use and application of the results. The set of indicators are based on the expert judgments and consensus of the project team and may be somewhat restricted by the available data. Different installations have different regional resource issues and differing missions; therefore, application of the data should be done with this in mind.

SIRRA has proven to be a useful and successful sustainability screening tool; its past use includes installation assessment in a decision-support function by the 2005 Base Realignment and Closure Commission.

USACE recognizes the need for a system-wide approach to ecosystem management in its efforts to provide environmental sustainability while being the mandated steward of the nation's water resources. As part of those efforts, in 2005 the USACE System-Wide Water Resources Program (SWWRP) sponsored ERDC-CERL's SIRRA developers to build a watershed application of SIRRA. This work characterized the nation's watersheds by using an updated and improved subset of SIRRA indicators. Several updates of this methodology were completed during 2008–2009. The USACE Actions for Change program sponsored the National Assessment for Sensitivity to Water Control project in fiscal year (FY) 2008. This project updated and improved the set of SIRRA indicators that are relevant to watershed health—the number of indicators was increased from 23 to 27, the scale and units for several indicators was changed, and additional indicators were added. The 607 USACE dam locations were mapped as an overlay on the base map of 2,252 HUC[3]-8 watersheds. A subsequent update of the watershed screening methodology applied the new set of 27 watershed indicators to the complete list of military installations contained in SIRRA. This application was sponsored by the Army Environmental Policy Institute in FY 2008. This updated national screening helped to identify vulnerable watersheds and prioritized regions for detailed water supply and demand assessments. The results of all SIRRA projects are available through the SIRRA website.[4]

[3] hydrological unit code

[4] http://datacenter.leamgroup.com/sirra/

2.3 Existing biofuel data portals

Several biofuel data portals exist today that provide users with comprehensive tools and data processing techniques for conducting comprehensive bioenergy planning. These portals are free data repositories and reporting resources which help organizations aggregate the collected data and extract it into useful formats. Described below are four of these portals. Each selected portal contain national datasets, are routinely updated, and thus are the most likely to contribute to the SIRRA Biofuel Application indicator set.

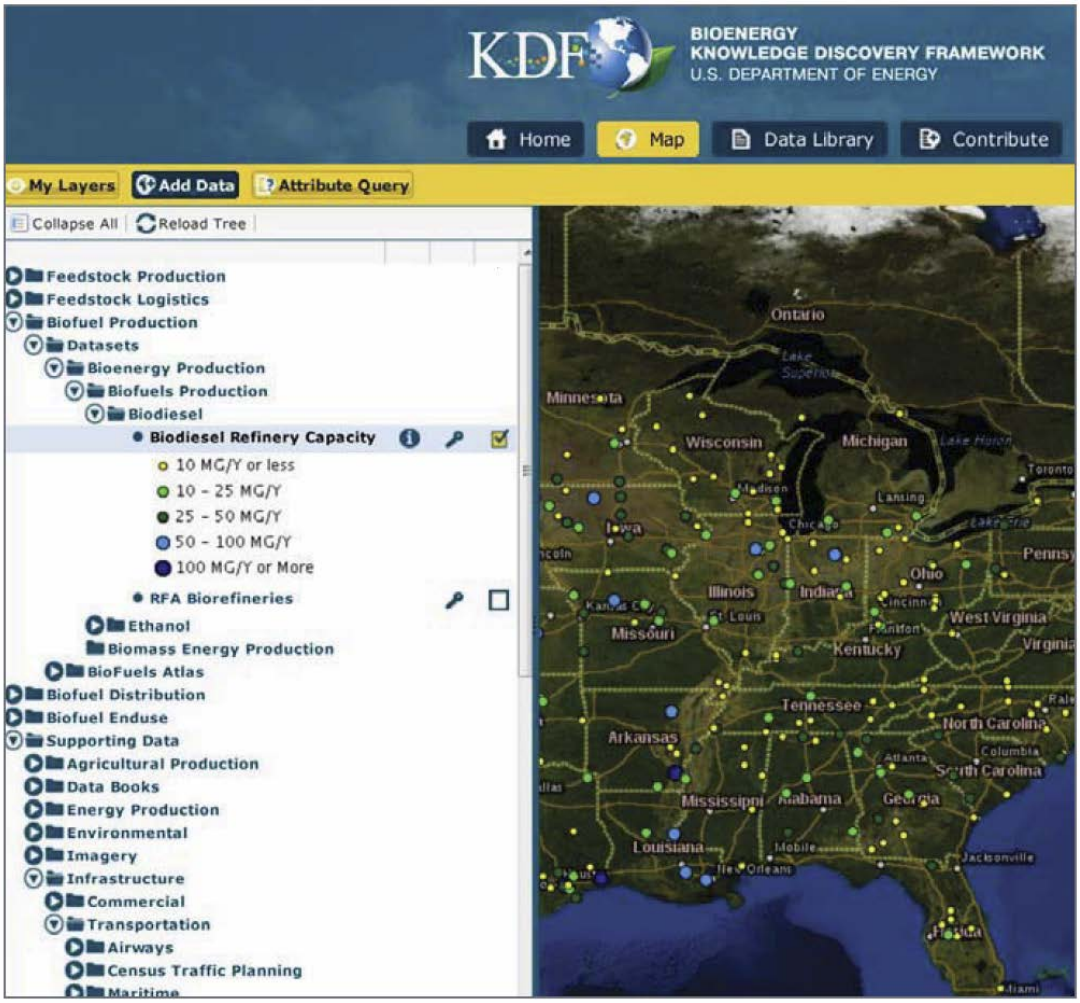
2.3.1 Bioenergy Knowledge Discovery Framework [weblink]

Developed by Oak Ridge National Laboratory, Argonne National Laboratory, and Idaho National Laboratory (INL) with university partners and under the direction of the Department of Energy's Biomass Program, the Bioenergy Knowledge Discovery Framework (KDF) provides a GIS-based framework for data collection, integration, and visualization (Figure 2). By pulling data, models, and simulations from the Biomass Program's research portfolio, the Bioenergy KDF helps users identify promising areas for feedstock production and processing, assess relevant infrastructure resources at multiple scales, and evaluate the potential for biofuels to meet legislated renewable-fuels targets. KDF structures its data under the following issue areas.

- Biofuel distribution
  - Alternative fuel stations
  - Ethanol market reports from Federal Trade Commission
  - Transportation networks—highway, railroad, waterways
- Biofuel end use
  - Census traffic planning
  - Ethanol industry outlook
  - Flex-fuel vehicles
  - Fuel stations
- Biofuel production
  - Biodiesel refinery
  - Ethanol refinery
- Feedstock logistics
  - INL resources
  - Transportation networks—highway, railroad, waterways

- Feedstock production
  - Bioenergy co-products
  - Bioenergy feedstocks

Figure 2. The online KDF interface.

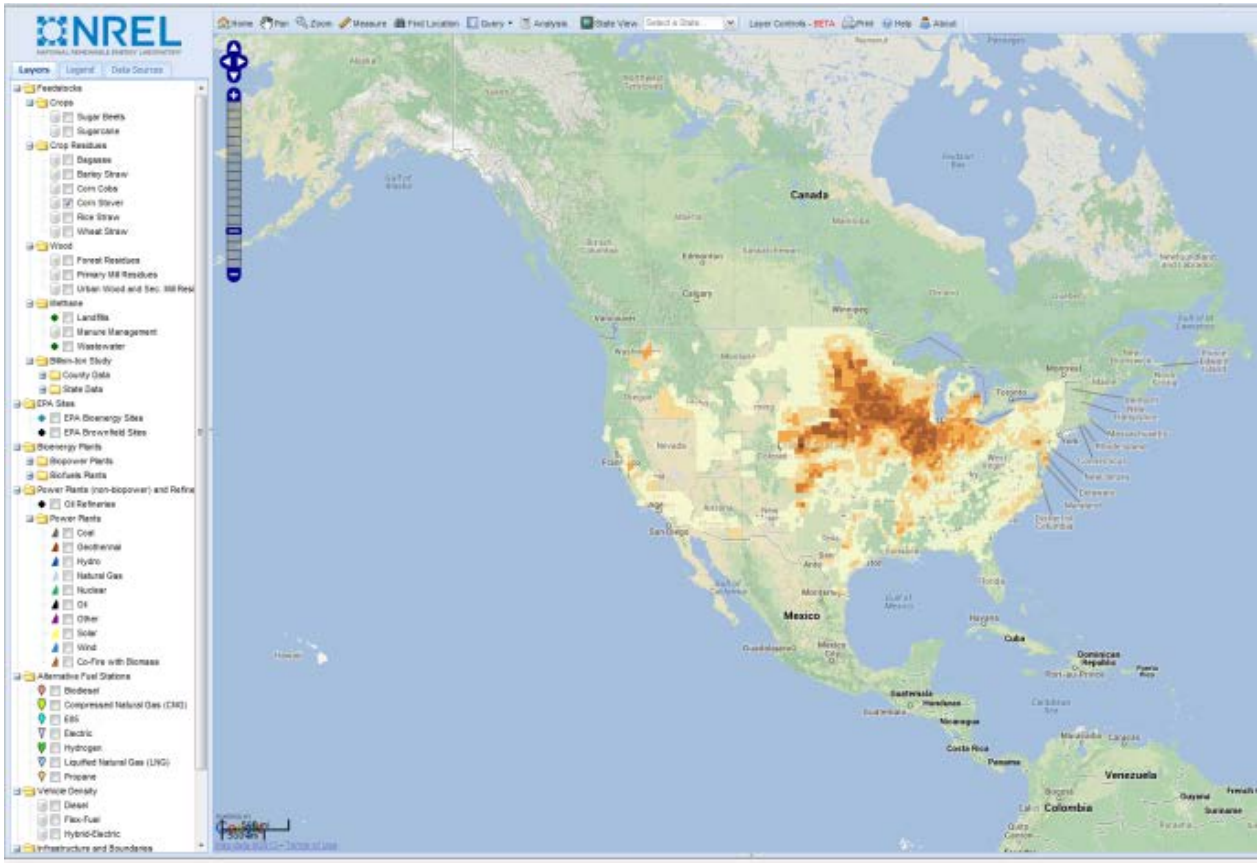


2.3.2 BioEnergy Atlas [weblink]

Maintained by the National Renewable Energy Laboratory (NREL) and built into Google Maps, the BioEnergy Atlas (Figure 3) includes two interactive maps, BioPower and BioFuels. These maps allow users to compare and analyze biomass feedstocks, biopower, and biofuels data from the U.S. Department of Energy (DoE), U.S. EPA, and the U.S. Department of Agriculture (USDA). The BioEnergy Atlas structures its data under the following issue areas.

- Feedstocks
  - Production
  - DoE Billion-Ton Study—county and state data
- EPA bioenergy sites
- EPA brownfield sites
- Biopower plants
- Biofuels plants
- Power plants
- Alternative fuel stations
- Vehicle density

Figure 3. Example of BioEnergy Atlas interface (http://maps.nrel.gov/bioenergyatlas/) .



2.3.3 Infrastructure Alternative Fuels Data Center [weblink]

The Alternative Fuels Data Center (AFDC) (Figure 4) provides information, data, and tools to help fleets and other transportation decision makers find ways to reduce petroleum consumption through the use of alternative and renewable fuels, advanced vehicles, and other fuel-

saving measures. The AFDC is a resource of the DoE Clean Cities program. AFDC structures its data under the following issue areas.

- Vehicles
  - Alternative-fuel vehicles (AFVs) and hybrid electric vehicles (HEVs)
  - Fuel consumption and efficiency
  - Market
  - Driving patterns
- Fuels and Infrastructure
  - Fuel trends
  - Alternative fueling stations
  - Transportation infrastructure
  - Biofuels production
  - Emissions
  - Idle reduction
- Regulated fleets
  - Federal fleets
  - State and alternative fuel providers
- Clean cities
  - Petroleum use reduction
  - Coalitions
  - Funding
  - Vehicles
- Laws and incentives

2.3.4 U.S. Energy Information Administration [weblink]

The U.S. Energy Information Administration (EIA) collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment (e.g., Figure 5). The EIA structures renewable and alternative fuels data under the following issue areas:

- Monthly Biodiesel Production Report
  - production capacity and production
  - production, sales, and stocks
  - inputs to biodiesel production
  - producers and production capacity by state
  - production by Petroleum Administration for Defense District
- Wood and Waste

- consumption of wood/wood waste products
- agricultural byproducts/crops
- other biomass products

- Municipal Solid Wastes and Landfill Gas
  - consumption of landfill gas
  - municipal solid waste
  - sludge waste
  - other waste energy sources
- Biofuels Overview
  - annual ethanol and biodiesel production
  - consumption
  - feedstock
  - net imports
- Alternative Transportation Fuels
  - number of vehicles by fuel type
  - plant production capacity

Figure 4. An Alternative Fuels Data Center online interface (http://www.afdc.energy.gov/locator/stations/).

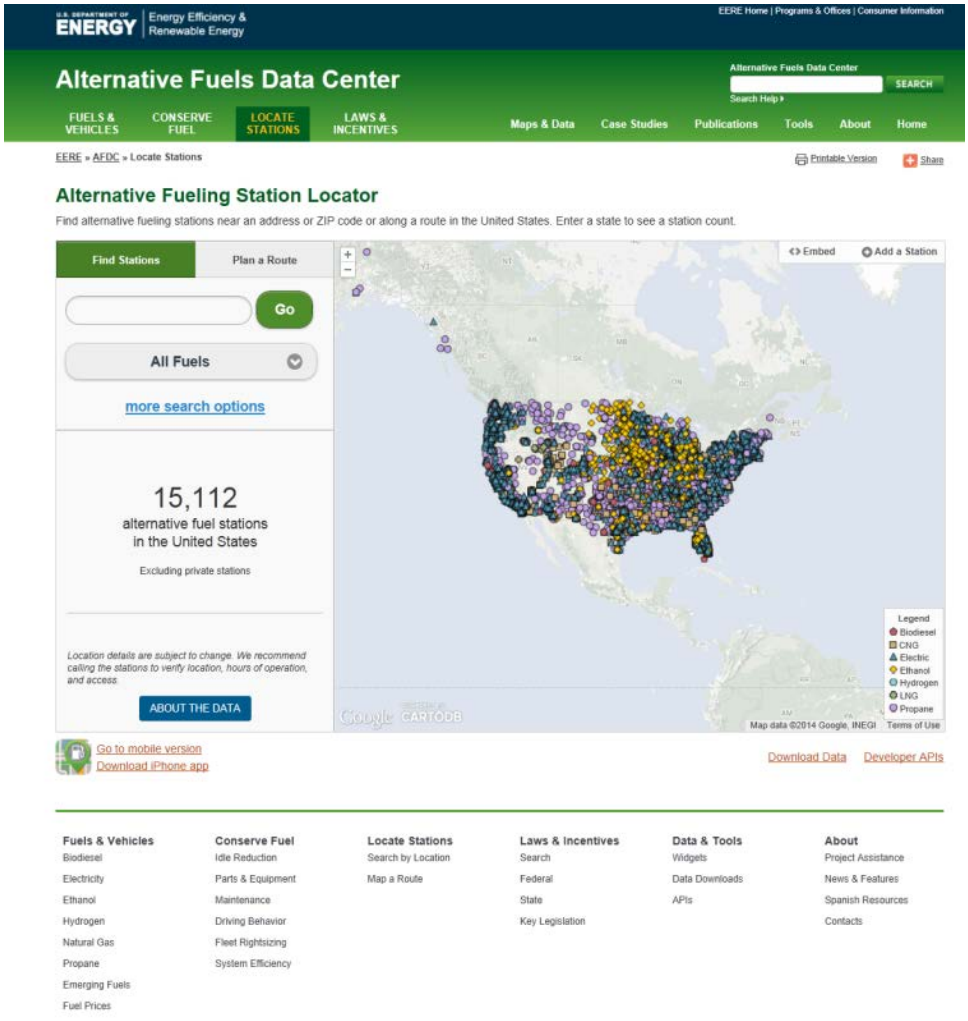
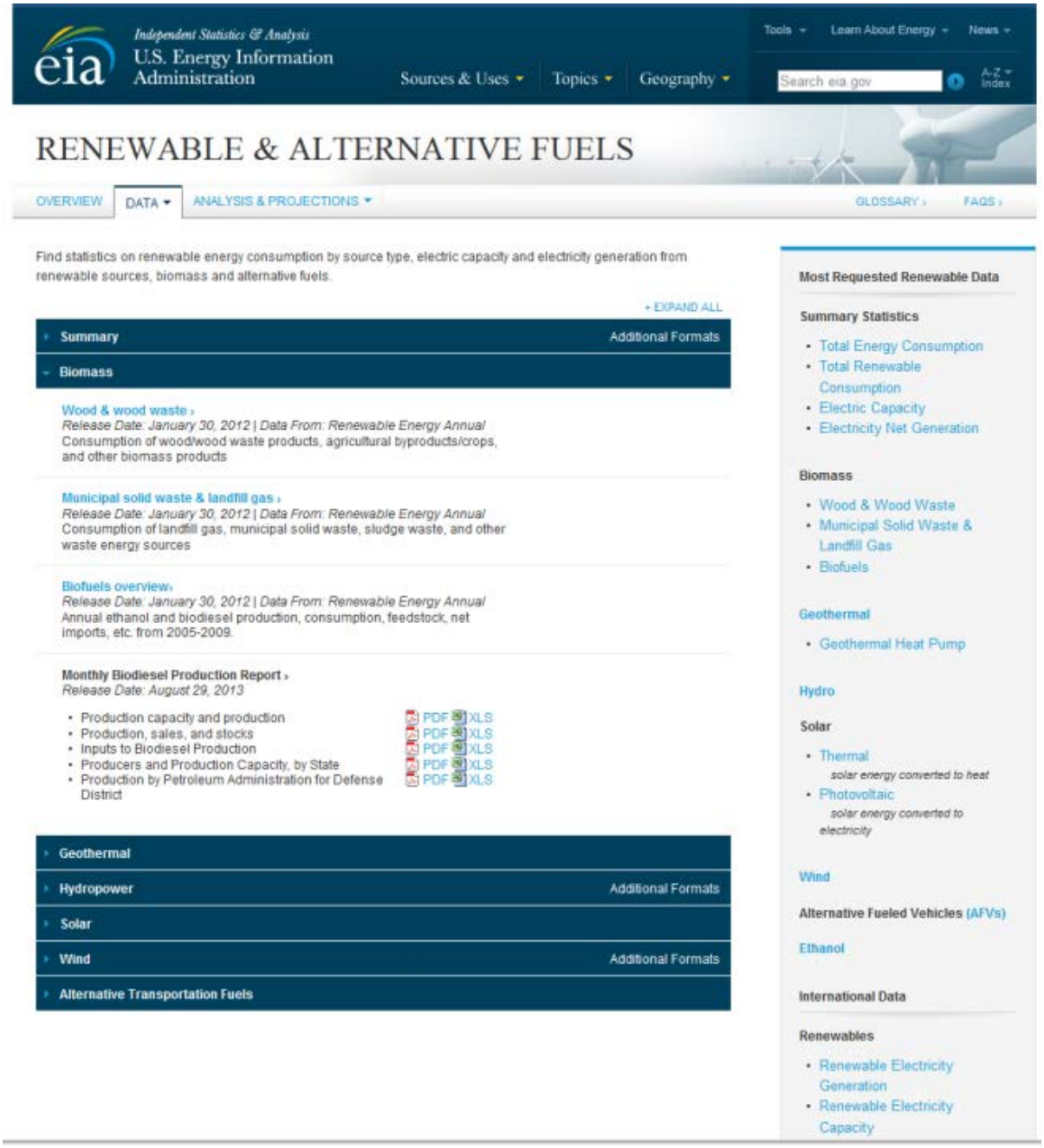


Figure 5. Example of data available online from the U.S. Energy Information Center (http://www.eia.gov/renewable/data.cfm#alternative).



3 USACE Business Line Suitability Analysis

In this chapter, eight USACE business lines are analyzed relative to their suitability for biofuel production and includes a summary of the suitability of each business line to biofuel production (see Table 2–Table 9). Descriptions of each business line and details of the related activities are contained in the subsections that follow each summary table.

3.1 Navigation

3.1.1 Description

The Navigation business line is responsible for ensuring safe, reliable, efficient, and environmentally sustainable waterborne transportation systems for the movement of commercial goods and national security purposes. It fulfills this responsibility through a combination of capital improvements and the operation and maintenance of existing infrastructure projects. The Navigation business line is vital to the nation's economic prosperity; for example, the use of its ports for America's international trade is 97% by volume and 64% by value (U.S. Army 2012, 2). Our nation's marine transportation system (MTS) also encompasses a network of Corps-maintained navigable channels, waterways, and infrastructure as well as publicly and privately owned vessels, marine terminals, intermodal connections, shipyards, and repair facilities. The MTS consists of approximately 12,000 miles of inland and intracoastal waterways with 220 locks at 171 sites; approximately 300 deep-draft and over 600 shallow-draft coastal and Great Lakes channels and harbors extending 13,000 miles and including 21 locks; and more than 900 coastal structures and 800 bridges (U.S. Army 2012, 2). The Corps maintains all of these entities.

Table 2 summarizes the FRM business line's suitability for biofuel production.

Table 2. Summary of the Navigation business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Navigation	Strong—numerous activity connections applicable across all USACE divisions and districts	Disposal of dredged materials	▪ CDF site locations ▪ CDF percentage capacity reached ▪ CDF area (acres)
		Bioremediation of dredged materials	▪ Types of CDF contamination ▪ Contaminated CDF site locations ▪ Species phytoremediation potentials (based on contaminants present) ▪ Plant species suitability/distribution (based on climate)
		Invasive aquatic vegetation	▪ Current infestation locations (based on remote imagery —e.g., LIDAR) ▪ Aquatic invasive plant species presence (by type and quantity) ▪ Aquatic invasive plant species risk (based on habitat suitability) ▪ Aquatic plant control program site locations (by type and quantity)
		Transportation of feedstock and biofuel	▪ Critical waterway links: a ranking of waterway segment importance to feedstock and biofuel transportation based on: proximity to feedstock sources; proximity to biofuel processing plant/distribution facility; proximity to rail and road ways; and proximity to end users/biofuel demand trends ▪ Proximity to interstate ▪ Proximity to railway

3.1.2 Activity: disposal of dredged materials

Maintaining reliable navigation systems is a necessary requirement for a healthy economy, a strong national defense, and a strong emergency response framework. Almost all maintenance of navigation systems is related to some type of dredging activity with requirements for relocation and/or placement (permanent or temporary) of the dredged materials (Bailey et al. 2010). Currently, three options for dredged material disposal exist: (1) open-water disposal, (2) confined (diked) disposal, and (3) beneficial use. The physical location of the dredging operations, potential contamination of the dredged material, and suitable alternatives for beneficial use often restrict disposal options to confined disposal facilities (CDF) as the most economical and environmentally acceptable alternative (Brandon and Price 2007). Confined disposal facilities are diked impoundments that vary in size from a few acres to more than 2,000 acres. They are extraordinarily expensive to design, permit, and construct. Locating suitable sites is difficult due to competitive land uses, land

availability, and local opposition to CDFs in general. Furthermore, many of the CDFs are at or near their capacity, thereby limiting future dredging projects along many U.S. waterways. As a result, there is a need to evaluate these facilities for multiple uses, among which might be biofuel production. Several species of invasive grasses (e.g., *Phragmites* and *Phalaris*) and aquatic weeds (e.g., *Hydrilla, Myriophyllum*, and *Eichhornia*) have been proposed for use as biofuel crops due to their biomass production potential in wetland and aquatic areas (Wilkie and Evans 2010). Floristic inventories of some older Great Lakes CDFs have indicated that these two grass species are naturally present in significant quantities and produce ample biomass yields on a seasonal basis (Price et al. 2005). Although vegetation is typically the least managed component of CDFs, it is nonetheless beneficial for a number of purposes including control of dust and volatilization losses, improved effluent quality, and efficient dewatering (Price et al. 2005). Because disposal of freshly dredged materials in CDFs creates very wet conditions that can require significant periods of dewatering, the use of perennial plants adapted to these types of conditions would potentially accelerate this process while concomitantly producing significant amounts of biomass.

3.1.3 Activity: bioremediation of dredged materials

More than 300 million cubic meters of sediment are dredged annually in order to maintain and improve navigation in U.S. waterways. Most of this material is considered uncontaminated (90%); however, sediments from waterways located near highly industrialized or urban areas can be contaminated by point and non-point sources of metals and various organic chemicals (Winfield and Lee 1999). Land treatment of the contaminated sediments in CDFs utilizes several types of bioremediation technologies in which contaminated soils are inverted through multiple tillage events and allowed to interact with the climate and vegetation (Myers and Williford 2000; Myers and Horner 2003). Bioremediation from land treatment occurs through photolysis, volatilization, and biodegradation (Myers 1996). Biodegradation can include the use of vegetation (phytoremediation) whereby plants are grown on contaminated and/or submerged dredged materials and uptake solubilized contaminants (Balsamo et al. 2012). Several species of plants already being considered as potential biofuel feedstock sources (e.g., *Salix, Populus, Phalaris, Phragmites, Helianthus*) are common vegetative components of contaminated CDFs, indicating their potential as phytoremediative biofuel feedstocks (Price et al. 2005; Ruiz-Felix et al. 2012).

3.1.4 Activity: invasive aquatic vegetation

For maintaining reliable navigation systems, control and management of aquatic invasive plant species is second only to dredging operations in terms of time and resources utilized within the USACE Navigation business line. Millions of acres of surface waters in the United States are infested with aquatic invasive plant species which impede commercial and recreational traffic through navigable waterways, block port ingress/egress, and exert dangerous pressure on transportation infrastructure (Jakubauskas et al. 2000). Millions of dollars are spent annually on aquatic plant control programs and the problems are logistically and economically severe enough that Congress authorized the USACE Aquatic Plant Control Research Program as the Nation's only federal program dedicated to the management of aquatic weeds (Gunkel and Barko 1998).

Control of aquatic nuisance species is usually accomplished by using chemical, biological, or mechanical/manual technologies. Chemical and biological control technologies each have their respective strengths, weaknesses, and regulatory concerns, but have little direct connection to biofuels and, thus, will not be discussed further in the context of this report. Mechanical/manual control technologies, however, involve the direct collection and manipulation of aquatic invasive plant species biomass which may have the potential to serve as feedstock for biofuel production. A wide variety of harvesting, chopping, and cutting machinery have been developed to remove, collect, and/or destroy aquatic vegetation (Madsen 2000; Greenfield et al. 2004). A recent study by Hronich et al. (2008) describes the harvesting of water hyacinth (*Eichhornia crassipes*) by using cutters and grappling hooks for collection and delivery of biomass for on-shore biofuels processing at similar costs ($50/ton) to the harvesting of switchgrass (*Panicum virgatum*) (Perrin et al. 2008). Another factor that makes aquatic invasive plant species attractive as biofuel feedstocks are their extraordinary primary productivity rates when compared to terrestrial plant species considered for biofuel feedstocks (Nigam 2002; Xu et al. 2012). Water hyacinth, for example, produces annual biomass yields in excess of 110 dry tons per acre (Hronich et al. 2008), whereas switchgrass yields seldom exceed 25 dry tons per acre (Bransby et al. 1998).

Other aquatic invasive vegetation types also lend themselves to harvesting and collection technologies that would make the biomass available for

biofuel processing and production (Wilkie and Evans 2010). Recognition that aquatic invasive plant species could well serve as sources of biomass feedstock for biofuel production has led to research whereby several genera of duckweed (*Lemna, Landoltia, Spirodela, Wolffia, Wolfiella*) have been evaluated for potential breeding and open-water production/harvesting programs, based on their high-protein content and inducible high-starch contents (Xu et al. 2012). Depending on the unique circumstances associated with specific water bodies, there may be potential opportunities for harvesting overgrown, nuisance, aquatic invasive species biomass in conjunction with routine maintenance of navigation waterways and systems.

3.1.5 Activity: transportation of feedstock and biofuel

Transportation of plant cellulosic biomass feedstocks to biofuel production facilities and distribution of refined products are significant costs to biofuel production. Clearly, the Corps waterways provide a key transportation link in the current supply chain that utilizes grain for ethanol production, oilseed crops for biodiesel production, and cellulosic biomass for other types of biofuel development. It is not unreasonable to suggest that these same waterways could also support additional feedstocks produced as a result of utilizing CDF-related biomass production and that associated with harvesting and collection of invasive aquatic vegetation, especially since these biomass sources are within or adjacent to existing navigation systems . The DoE supports a number of modeling efforts that optimize biofuel transportation networks (e.g., Bioenergy Knowledge Discovery Framework; see Figure 2). Assuring that the Corps' waterway networks are adequately represented and available as input data for these existing models would result in more comprehensive model outputs concerning the relationship between transportation networks and feedstock/biofuel production.

3.1.6 Example activity

Invasive Aquatic Vegetation. There is a wide variety of mechanical harvesting equipment available for harvesting and collecting aquatic nuisance/invasive species biomass (Haller 2009; Lembi 2009). Most of the available harvesting equipment involves activities like shredding, mowing, chaining, or cutting (Haller 2009), usually in combination with a conveyor system and barge for collection and transport of harvested biomass. There are numerous commercial companies that conduct this

type of contract work; however, the end use of collected biomass as feedstock for biofuels is seldom considered. The USACE Aquatic Plant Control Research Program has a predictive model that can be used to plan harvesting operations to maximize plant control efficiency or peak standing biomass, depending on project objectives. The model allows users to evaluate different types of equipment and to develop cost and time estimates.

3.2 Flood Risk Management

3.2.1 Description

The Flood Risk Management (FRM) business line works to reduce the risk to human safety and property damage in the event of floods and coastal storms. The CW directorate has constructed 8,500 miles of levees and dikes, 383 reservoirs, and more than 90 storm damage-reduction projects along 240 miles of the nation's 2,700 miles of shoreline. With the exception of reservoirs, most infrastructure that is built under the auspices of FRM is transferred upon completion to the sponsoring cities, towns, and special-use districts that own and operate the projects.

Over the years, the Corps' mission of addressing the causes and impacts of flooding has evolved from flood control and prevention to more comprehensive FRM. These changes reflect a greater appreciation for the complexity and dynamics of flood problems—the interaction of natural forces and human development—as well as for the federal, state, local, and individual partnerships needed to thoroughly manage the risks caused by coastal storms and heavy rains.

FRM is the process of identifying, evaluating, selecting, implementing, and monitoring actions to mitigate levels of risk. Its goal is to ensure scientifically sound, cost-effective, integrated actions that reduce risks while taking into account social, cultural, environmental, ethical, political, and legal considerations. The Corps' approach to FRM relies on productive collaborations with partners and stakeholders (e.g., the Federal Emergency Management Agency [FEMA]), the Department of Housing and Urban Development (HUD), the National Oceanic and Atmospheric Administration (NOAA), affected state agencies, sponsors, and citizens. Effectively and efficiently, these collaborations heighten the nation's awareness of flood risks and consequences.

The FRM business line has compiled an impressive record of performance, yielding a six-to-one return on investment; that is, the business line saves six dollars for each dollar spent. It has also helped reduce the risk to human safety by providing timely flood warnings that afford sufficient time for evacuation. Table 3 summarizes the FRM business line's suitability for biofuel production.

Table 3. Summary of the Flood Risk Management business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Flood Risk Management	Moderate—one key activity connection applicable across all USACE divisions and districts.	Nuisance aquatic vegetation	▪ Flood management infrastructure site locations (e.g., reservoir, levee, dike, and dock) ▪ Aquatic invasive plant species presence ▪ Aquatic invasive plant species risk ▪ Aquatic Plant Control Program site locations
		Flood prevention and impact control	▪ Flood risk areas ▪ Water quality (based on polluted waterways and flow sensitivity) ▪ Water availability (based on groundwater depletion and level of development) ▪ Soil quality (based on compaction, nutrient, and water level) ▪ Erosivity (erosion risk areas)

3.2.2 Activity: nuisance aquatic vegetation

Many reservoirs constructed for flood management and control also serve as sources of drinking water for hundreds of municipalities and provide significant recreational opportunities and economic returns to nearby communities. As with the Navigation business line, management and control of nuisance and/or invasive aquatic vegetation is an important aspect of the FRM business line. Masses of floating aquatic vegetation in reservoirs can exert tremendous pressure on flood management infrastructure such as levees, dikes, dock areas, and piers, especially since some aquatic plant species can double their biomass in as little as six days (Nohara 1991; Kirk and Henderson 2006). The immense weight of aquatic plant biomass propelled by currents, wind, and wave action has the capability to compromise the integrity of this infrastructure and render it ineffective, unsafe, and expensive to repair (Barrett 1989). Further, as a major factor in efficient water movement, storage, and release, the accumulated aquatic plant biomass can substantially reduce water

movement; this reduction in movement results in unwanted impoundment and flooding that the original structural flood management solutions were intended to mitigate (Kirk and Henderson 2004). In reservoirs prone to regular and seasonal infestations of aquatic nuisance or invasive vegetation, harvesting and collection technologies that enable beneficial use of the resultant biomass as feedstock for biofuel production could be economically justified, depending on proximity to biofuel transportation and processing infrastructure.

3.2.3 Activity: flood prevention and impact control

Residents living near levees, dikes, reservoirs, and other types of storm damage-reduction projects have expressed serious concerns about water quality and soil conservation issues (Kasul et al. 1998). Given these concerns and the limited types of production agriculture systems that can be imposed on FRM and storm damage-reduction projects, development of compatible land-use plans with adjacent landowners should be considered. These types of collaborative, adaptive land-use planning exercises frequently identify vegetation management strategies that can enhance project functionality by maximizing plant cover, thereby minimizing overland flow and sheet erosion, encouraging water infiltration, protecting water quality, and providing wildlife habitat. Integrating native grass cellulosic feedstock production as a component of collaborative, adaptive vegetation-management strategies within FRM and storm damage-reduction projects appears to be a worthwhile consideration with significant project and non-project benefits (Walters 1997).

3.2.4 Example activities

See discussion in Section 3.1.4 on page 19.

3.3 Environment

3.3.1 Description

The Corps has three distinct areas that are focused on the environment: (1) aquatic ecosystem restoration; (2) stewardship of USACE lands; and (3) the Formerly Utilized Sites Remedial Action Program (FUSRAP). Financial information in the following description was taken from a 2012 annual USACE financial report (U.S. Army 2012).

Aquatic ecosystem restoration. The Corps' mission in aquatic ecosystem restoration is to help restore aquatic habitat to a more natural condition in ecosystems in which structure, function, and dynamic processes have become degraded. The emphasis is on restoration of nationally (or regionally) significant habitats where the solution primarily involves modifying the hydrology and geomorphology. In FY 2012, Aquatic Ecosystem Restoration received approximately $524 million, which translates to just over 10% of the total USACE appropriation.

Environmental stewardship. Environmental Stewardship focuses on managing, conserving, and preserving natural resources on 11.5 million acres of land and water at 456 multipurpose USACE projects. Corps personnel monitor water quality at the Corps' dams and operate fish hatcheries in cooperation with state wildlife agencies. This business line encompasses compliance measures to ensure Corps' projects will: (1) meet federal, state and local environmental requirements; (2) sustain environmental quality; and, (3) conserve natural and cultural resources. In FY 2012, Environmental Stewardship received $97 million, an amount comprising 1.9% of the total USACE appropriation.

FUSRAP. Under the FUSRAP, the Corps cleans up former Manhattan Project and Atomic Energy Commission sites, making use of expertise gained in cleansing former military sites and civilian hazardous waste sites under the EPA's Superfund Program. In FY 2012, the FUSRAP received $109 million, or approximately 2.2% of the total USACE appropriation.

Table 4 summarizes the Environment business line's suitability for biofuel production.

Table 4. Summary of the Environment business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Environment	Strong—numerous activity connections applicable across all USACE divisions and districts.	Invasive vegetation	▪ Aquatic ecosystem restoration site locations ▪ Invasive plant species presence (by type and quantity of both aquatic and terrestrial species) ▪ Invasive plant species risk (based on habitat suitability maps of both aquatic and terrestrial species)
		Vegetation management:	▪ Vegetation management site locations

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
		Phytoremediation	▪ Hazardous/FUSRAP waste site locations ▪ Phytoremediation potential ▪ Plant species suitability/distribution
		Habitat management	▪ TES presence (by type) ▪ TES hotspot ▪ Agricultural outlease site locations ▪ Plant species suitability/distribution ▪ Wetland/riparian site locations ▪ Fish richness ▪ Erosivity (erosion risk areas) ▪ Water quality ▪ Water availability
		Forest and grassland management	▪ Forest site locations ▪ Grassland site locations ▪ Recreation site locations ▪ Agricultural outlease site locations ▪ Recreation site locations ▪ Plant species suitability/distribution

3.3.2 Activity: invasive vegetation

Aquatic ecosystem restoration frequently involves modifying the hydro-geomorphology of an area to restore the structure and function of important aquatic systems. Frequently, these types of projects require removing invasive plant species and revegetating the site with native species. Several invasive plants species, most notably *Phalaris, Phragmites,* and *Tamarisk*, produce prodigious amounts of biomass that must be harvested and removed when aquatic ecosystems are restored. Although biomass is only harvested once, the mass is often significant enough to merit consideration for use as a feedstock in biofuel production if transportation and processing facilities are available within a feasible radius.

3.3.3 Activity: vegetation management

USACE manages natural resources on 11.5 million acres of land and water across the United States. Many of these managed landscapes require significant amounts of vegetation management to achieve stewardship goals. Examples include terrestrial plant control whereby these species are often harvested and removed to prevent further seed distribution and to reduce potential wildfire hazards associated with downed vegetation. Depending on the region, the biomass harvested from these types of

vegetation management activities can be substantial. Although the biomass can't be harvested with any degree of predictability and the frequency of harvesting is often very low, the sheer amount of biomass that can be harvested suggests that its potential for biofuels feedstock should be considered.

3.3.4 Activity: phytoremediation

Plants with rapid growth and biomass accumulation rates are readily available for almost any climate in the United States where FUSRAP sites are located. Many of these species have been evaluated for their potential to uptake specific types of contaminants and their ability to passively phytoremediate contaminated sites over long periods of time. Several researchers have documented promising dual-use plants that have characteristics suited for contaminant uptake along with growth rates and characteristics suited to biomass production for use as biofuel feedstocks (Ruiz-Felix et al. 2012). Under scenarios where plants are continuously cultivated and harvested, a link to biofuel processing may be easier to make because of the predictability and frequency associated with this type of production system. Not all contaminated sites will support vigorous plant growth; however, there are many circumstances where acceptable plant growth is possible, and dual-use plants should be investigated for potential utilization.

3.3.5 Activity: Habitat management

Water quality concerns are also a very high priority at many Corps' dams, because significant deterioration can result from invasive aquatic vegetation. Several studies have documented extremely low dissolved oxygen concentrations in lakes infested by invasive aquatic plants, thereby limiting habitat requirements for sport fish species (Colle et al. 1987), affecting water inputs for fish hatcheries (Durocher et al. 1984), and producing conditions favorable for transmission of waterfowl diseases (Wilde 2004). Again, depending on: the severity of the infestation, access to harvesting and collection equipment, and proximity to transportation and biofuels processing plants, use of aquatic plant biomass as a feedstock may be warranted.

Riparian, wetland, and upland terrestrial systems are significant components of most multi-purpose Corps projects. Embedded within the management strategies for forests, grasslands, riparian zones, and

agricultural outleases are provisions for wildlife management efforts designed to establish and maintain desirable mixtures of habitat types and successional niches that will benefit the greatest number of species (Kasul et al. 1997). Some common examples of these wildlife management efforts include food plots, canopy manipulation, prescribed burning, and agricultural crop/haying/grazing specifications. Each of these land-use management practices has favorable impacts that range from reducing sediment yields and nutrient loading that can negatively affect water quality to improving vegetation structure and composition that ultimately improves infiltration, percolation, and retention of precipitation. There are probably specific project sites/areas where establishment and management of native grass plantings could be considered for the purpose of supporting cellulosic feedstock production and the concomitant improvements to wildlife habitat and erosion control that would accompany these plantings.

3.3.6 Activity: forest and grassland management

See Section 3.7.4 on page 33.

3.3.7 Example activity: vegetation management

Vegetation management projects are common across several USACE business lines including Recreation, Environment, and Flood Risk Management. Invasive or nuisance vegetation is frequently targeted for removal to improve wildlife habitat, provide corridors for flood control projects (e.g., Chena River Lakes, Alaska), and to improve water supply and delivery through the reduction of invasive vegetation types that flourish around riparian areas and along water delivery canals (e.g., USACE and Texas Water Development Board collaborative feasibility studies for the Nueces River Basin, the Sulphur River Basin, and the Middle Brazos River Basin). Numerous reservoirs have experienced significant encroachment by phreatophytic (water-loving) trees and shrubs, necessitating control measures to increase water availability and restore native ecosystems. These species have extremely high rates of transpiration and low water-use efficiency, which can exacerbate the effects of drought on reservoir water levels (e.g., O.C. Fisher Lake Ecosystem Restoration Project, San Angelo, Texas—a USACE 2005 project).

3.4 Regulation of Aquatic Resources

In accordance with the Rivers and Harbors Act of 1899 (Section 10)[5] and the Clean Water Act of 1972[6] (Section 404) as amended, the Corps' regulatory program regulates work in, over, and under navigable rivers as well as regulates the discharge of dredged and fill material into U.S. waters (including wetlands). The Corps implements many of its oversight responsibilities by means of a permit process. Throughout the permit evaluation process, the Corps complies with the National Environmental Policy Act and other applicable environmental and historic preservation laws. In addition to federal statutes, the Corps also considers the views of other federal, tribal, state and local governments, agencies, and interest groups, as well as the general public when rendering its final permit decisions. Regulatory responsibilities include evaluating minor activities such as driveways for small landowners as well as large water supply and energy project proposals which affect billions of dollars of the nation's economy.

Table 5 summarizes the suitability of the Regulation of Aquatic Resources business line's suitability for biofuel production.

Table 5. Summary of the Regulation of Aquatic Resources business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Regulation of Aquatic Resources	Very Weak— This business line is mostly regulatory in nature and the connections to biofuel production would only be tangential or circumstantial depending upon the specifics of the permit application and evaluation.	Not applicable	Not applicable

[5] 33 U.S. Code § 403

[6] 33 U.S.C. §1251 et seq.

3.5 Emergency Management

3.5.1 Description

Throughout USACE history, the United States has relied on the Civil Works Program in times of national disaster. Emergency management continues to be an important part of the CW Program, which directly supports the Department of Homeland Security in carrying out the National Response Framework. It does this by providing emergency support in public works and engineering and by conducting emergency response and recovery activities under authority of the Flood Control and Coastal Emergency Act (P.L. 84-99). In a typical year, the Corps responds to more than 30 disaster declarations by the U.S. president; its highly-trained workforce is prepared to deal with both manmade and natural disasters.

The Corps not only contributes to domestic emergency management efforts, but it also plays a major role on the international stage through its participation in civil-military emergency preparedness. In support of the Department of Defense, the Corps shares emergency management knowledge and expertise with U.S. allies and with partners in the former Soviet republics and Eastern Europe. This valuable program brings together key leaders and builds relationships among nations in direct support of the National Defense Strategy.

Table 6 summarizes the Emergency Management business line's suitability for biofuel production.

Table 6. Summary of the Emergency Management business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Emergency Management	Moderate—tangential activity connections applicable across all USACE divisions and districts.	Debris management	▪ Natural Disaster Risk (based on historic incidence/type and future trends) ▪ Hurricane risk ▪ Flood risk
		Relief efforts	▪ Natural disaster risk

3.5.2 Activity: debris management

The aftermath of nearly every natural disaster over the past 20 years has involved significant amounts of time and resources allocated to debris management. In certain storm-impacted areas, woody materials are the primary debris type and could be investigated for potential diversion into biofuel production systems. With some forethought regarding potential debris collection and storage locations that could be used in the event of a natural disaster, locations with favorable access to transportation and proximity to biofuel production facilities could be preselected for service immediately following a requirement for emergency management.

3.5.3 Activity: relief efforts

Biofuels can provide an alternative or backup energy source during emergency situations. Regional partnerships should be considered whereby potential sources of biofuels could be identified and mobilized to support emergency operations. Discussions should also include considerations for how to offset biofuels used during emergency operations with those produced from the utilization of debris feedstock. Discussions should take place with regional partners to identify any potential feedstock source within the region.

3.5.4 Example activities

None were found.

3.6 Hydropower

3.6.1 Description

The Corps' multipurpose authorities provide hydroelectric power as an additional benefit of projects built for navigation and flood control. The Corps is the largest owner-operator of hydroelectric power plants in the United States, and one of the largest in the world. The Corps operates 350 generating units at 75 multipurpose reservoirs (mostly in the Pacific Northwest), and they account for about 24% of America's hydroelectric power and approximately 3% of the country's total electric-generating capacity. These hydroelectric plants produce nearly 70 billion kilowatt-hours each year, which is sufficient to serve nearly 7 million households or roughly 11 cities the size of Seattle, Washington. Hydropower is a

renewable source of energy, producing none of the airborne emissions that contribute to acid rain or the greenhouse effect.

Table 7 provides a summary of the Hydropower business line's suitability for biofuel production.

Table 7. Summary of the Hydropower business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Hydropower	Weak—all activity connections are more closely related to other USACE business lines, most notably Recreation, Flood Risk Management, and Environment.	Nuisance aquatic vegetation	• Flood management infrastructure site locations • Aquatic invasive plant species presence • Aquatic invasive plant species risk • Aquatic Plant Control Program site locations
		Protect altered wildlife	• Hydropower site locations

3.6.2 Activity: nuisance aquatic vegetation

There have been instances where mats of floating vegetation have been sucked into intake screens and turbines, effectively shutting down hydropower for a period of time. For additional information, please see Section 3.1.4 (page 19) and Section 3.2.2 (page 22). If there are hydropower locations where nuisance aquatic vegetation is commonplace, the potential for harvesting and collecting the vegetation should be investigated.

3.6.3 Activity: protect altered wildlife

See the discussion in Section 3.3.5 on page 26.

3.6.4 Example activities

See Section 3.1.4 on page 19.

3.7 Recreation

3.7.1 Description

The Corps is an important provider of outdoor recreation, which is an ancillary benefit of its flood prevention and navigation projects. The Corps' Recreation business line provides quality outdoor, public recreation

experiences in accordance with its three-part mission to: (1) serve the needs of present and future generations; (2) contribute to the quality of American life; and (3) manage and conserve natural resources consistent with ecosystem management principles.

The Corps administers 4,248 recreation sites at 422 projects on 12 million acres of land. During FY 2012, 10% of the U.S. population visited a Corps' project at least once. These visitors spent $16 billion pursuing their favorite outdoor recreation activities, which, in turn, supported some 270,000 full-time and part-time jobs.

Table 8 provides a summary of the Recreation business line's suitability for biofuel production.

Table 8. Summary of the Recreation business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Recreation	Moderate—numerous activity connections are more applicable to other USACE business lines, most notably Environment and Flood Risk Management.	Vegetation management	▪ Vegetation management site locations
		Invasive/nuisance aquatic vegetation	▪ Flood management infrastructure site locations ▪ Aquatic invasive plant species presence ▪ Aquatic invasive plant species risk ▪ Aquatic Plant Control Program site locations
		Forest and grassland management	▪ Forest site locations (specifically those with brush removal) ▪ Grassland site locations ▪ Agricultural outlease site locations ▪ Recreation site locations (by type and location) ▪ Plant species suitability/distribution

3.7.2 Activity: vegetation management

See Section 3.3.3 (p 25) and Section 3.3.5 (p 26).

3.7.3 Activity: invasive/nuisance aquatic vegetation

Some of the lakes and reservoirs have aquatic invasive plant issues as discussed under the Navigation and Flood Risk Management business line.

3.7.4 Activity: forest and grassland management

USACE has constructed hundreds of water resource development projects in more than 40 states. The diversity of these projects is impressive, ranging from large (300,00 acres), multipurpose reservoirs along the Missouri, Mississippi, Ohio, and Columbia Rivers to small (5,000 acres) reservoirs scattered along minor river systems in other parts of the United States (Kasul et al. 1998) Through a series of legislative acts in the 1960s and 1970s,[7] the Corps has been provided with mandates and broad authority to establish sustainable natural resources management programs that encompass and focus nearly equal efforts on both water and terrestrial resources. Terrestrial resources management frequently includes riparian areas adjacent to reservoir and navigation projects, upland areas required for continuity of project functions and boundaries,

[7] Forest Cover Act (P.L. 86-717), Federal Water Project Recreation Act (P.L. 89-72), and Endangered Species Act (P.L. 93-205).

and wetland areas which have been protected, restored, or created by the original water resources development project. Many of these terrestrial areas are relatively large, contiguous land masses which currently support forests, grasslands, and agricultural outleasing activities consisting of grazing, haying, and crop production. Multiple use to support recreation, endangered species habitat, wildlife, wildfire protection, erosion control, forestry, grazing, and crop production all require some type of vegetation management and/or manipulation to achieve the desired end. Wildfire management often consists of fuel reduction activities that produce significant amounts of unwanted biomass that could be diverted to biofuel production. With conscientious planning, agricultural outleasing contracts could be developed to exploit the growth and harvesting of cellulosic feedstocks along with the wildlife benefits that accrue from these types of perennial native grass plantings (Mitchell et al. 2010). These biofuel connection considerations are important to make given the proximity of most Corps water resource development projects to highly urban areas. Kasul et al. (1998) indicate that 80% of all Corps water resources development projects are within 50 miles of a metropolitan area, suggesting that efficient and cost-effective transportation networks for movement of biomass feedstocks to biofuel processing facilities already exist and could be quickly utilized.

3.7.5 Example activities

None were found.

3.8 Water Storage for Water Supply

3.8.1 Description

Conscientious management of the nation's water supply is critical to limiting water shortages and lessening the impact of droughts. The Corps has an important role to play in ensuring that homes, businesses, and industries nationwide have enough water to meet their needs. The Corps retains authority for water supply in connection with construction, operation, and modification of federal navigation, flood damage reduction, and multipurpose projects.

Table 9 provides a summary of the Water Storage for Water Supply business line's suitability for biofuel production.

Table 9. Summary of the Water Storage for Water Supply business line's suitability for biofuel production.

Business Line	Connection to Biofuel Production	Activities	Candidate Indicators
Water Storage for Water Supply	Weak—all activity connections are more closely related to other USACE business lines, most notably Flood Risk Management, Recreation, and Environment.	Not applicable	Not applicable

3.8.2 Example activities

Please see the discussion in Section 3.3.7 on page 27.

4 Conclusions and Recommendations

4.1 SIRRA Biofuel Application candidate indicators

Table 10 is a consolidation of candidate indicators. It represents a first cut at the development of a SIRRA Biofuel Application. Under the SIRRA approach, indicators are grouped by issue areas. Figure 6 provides an example indicator map.

Table 10. SIRRA Biofuel Application candidate indicators.

Production	USACE Project / Managed Site
Proximity to processing plant	CDF site locations
Plant species suitability/distribution	CDF area (acres)
Invasive plant species presence	Types of CDF contamination
Invasive plant species risk	Contaminated CDF site locations
Aquatic invasive plant species presence	CDF percentage capacity reached
Aquatic invasive plant species risk	Flood management infrastructure site locations
Demand / End Use	Wetland/riparian site locations
Total energy consumption	Aquatic ecosystem restoration site locations
Bioenergy consumption	Aquatic plant control program site locations
Bioenergy consumption growth rate	Vegetation management site locations
Population growth rate	Hazardous or FUSRAP waste site locations
Environmental	Hydropower site locations
Water availability	Forest site locations
Water quality	Grassland site locations
Soil quality	Recreation site locations
Phytoremediation potential	Agricultural outlease site locations
Erosivity (erosion risk areas)	**Laws and Incentives**
TES presence	Energy legislation
TES hotspot	Biofuel incentives
Fish richness	Biofuel coalitions
Natural disaster risk	**Economy**
Hurricane risk	Unemployment
Flood risk	Agricultural economic sector condition

Table 10 (cont'd). SIRRA Biofuel Application candidate indicators.

Transportation
Critical waterway links
Proximity to interstate
Proximity to railway

Production. These indicators present potential feedstock source locations. Indicators are primarily related to activities associated with the removal of current and future invasive or nuisance vegetation. These activities are present within the Navigation, Flood Risk Management, Hydropower, Recreation, and Environment business lines. The "proximity to processing plant" indicator addresses the relationship between feedstock sources relative to production facilities. Transportation costs associated with moving feedstock have a significant economic impact on feedstock-based biofuel production.

Demand/end use. As discussed in Chapter 2, outside pressures are likely to influence USACE's engagement in biofuel production. One such pressure is regionally increasing energy demands. Candidate indicators support the identification of regions where specific bioenergy demands are increasing as well as regions where overall energy consumption is rising and thus may become a target region for development of bioenergy sources.

Environmental. These indicators are aimed at identifying areas where biofuel production may enhance environmental stewardship and sustainability. These activities include habitat management, flood management, phytoremediation, and debris management. The associated business lines include Flood Risk Management, Environment, and Emergency Management.

Transportation. Again, transportation costs associated with moving feedstock have a significant economic impact on feedstock-based biofuel production. These indicators focus on identifying USACE-managed waterways that are critical to supporting the biofuel transportation network. The applicable business line is Navigation.

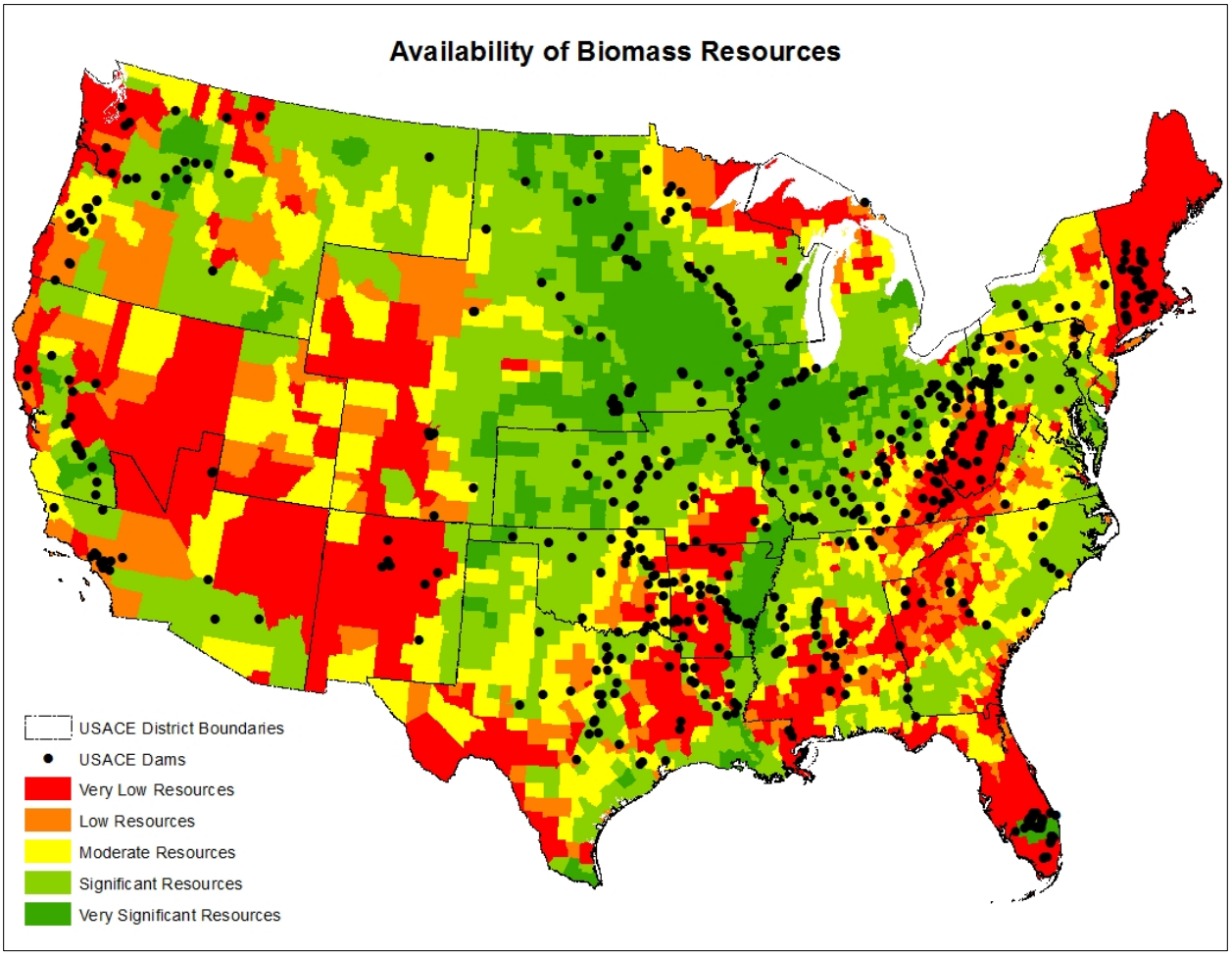
USACE Project/Managed Site. These indicators identify USACE sites where biofuel production activities are suspected to occur. They cross

nearly every business line including Navigation, Flood Risk Management, Environment, Hydropower, and Recreation.

Laws and incentives. These indicators characterize the regional legal environment and sentiment toward bioenergy. The presence of legislation, incentives, and/or coalitions can affect the type and intensity of biofuel activities.

Economy. These indicators specify regional economic pressures. Bioenergy is often pursued for rural economic development. Candidate indicators were included based on the national biofuel production considerations discussed in Chapter 2.

Figure 6. Example of a SIRRA Biofuel Application map. [8]



[8] Data drawn from the National Renewable Energy Laboratory "Crop residues five-year average, 2003-2007." As a surrogate measure, cellulosic biomass would be expected to show similar trends to those shown for crop residues. Overlaying USACE dams quantifies the regional feedstock production potential surrounding USACE managed sites.

Table 11 assesses the feasibility of developing the candidate indicators. Using CorpsMap,[9] it was first determined if the indicator data is currently maintained by USACE; if not, potential data sources were discussed. Overall, it was determined that data for 47% of candidate indicators currently exist in CorpsMap, and all candidate indicators have data sources that potentially could be maintained in CorpsMap. It is important to note that although the indicator may be available in CorpsMap (or SIRRA), it may not be maintained at an appropriate scale or measure for biofuel application. Several indicators are noted for requiring significant development. These indicators include: plant species suitability and distribution (based on species information and climate data), presence and risk of plant species (based on satellite imagery), critical waterway links (based on transportation modeling), and phytoremediation potential (based on contaminants information). All the USACE-managed sites are believed to be available through the Corps Project Notebook; however, the frequency of updates to this system is unknown. Demand/End Use, Laws and Incentives, and Economy issue area indicators are readily available on existing bioenergy portals. Many of the environmental indicators currently exist within SIRRA and thus, benefit from previous development. Table 11 supports an argument that developing a relevant indicator set is plausible and would require a moderate level of effort.

Table 11. Development potential for SIRRA Biofuel Application candidate indicators.

Candidate Indicator	Data Exists in CorpsMap	Potential Data Sources
Production		
Proximity to processing plant	N	**NREL**. Biofuel Plants dataset.
Plant species suitability/distribution	N	**FWS, NatureServe, USDA PLANTS database, JAWRA, Satellite Imagery**. These indicators are available from a variety of sources with varying pros and cons of the datasets. Specific indicator definitions and calculation development is required.
Invasive plant species presence	N	
Invasive plant species risk	N	
Aquatic invasive plant species presence	N	
Aquatic invasive plant species risk	N	
Demand / end use		
Total energy consumption	N	**Energy Information Administration**. A great deal of detailed consumption and
Bioenergy consumption	N	

[9] http://geoplatform.usace.army.mil/home/

Candidate Indicator	Data Exists in CorpsMap	Potential Data Sources
Bioenergy consumption growth rate	N	production data are available at the national spatial scale and annual temporal scale. Limited data are available at finer scales. Tabular data would need to be associated with spatial maps.
Population growth rate	N	**U. S. Census Bureau**. Development requires specific calculations. SIRRA has defined this calculation process.
Environmental		
Water availability	N	**SIRRA**. SIRRA offers multiple indicators to assess water availability under the water sustainability issue area.
Water quality	N	**SIRRA**. "Water Quality" dataset.
Soil quality	Y	**NRCS.** SSURGO dataset.
Phytoremediation potential	N	**NRCS**. Utilizing soil and plant databases, this indicator requires data calculations that are currently undefined.
Erosivity (erosion risk areas)	Y	**NRCS**. SSURGO "Site Degradation Susceptibility" dataset.
TES presence	Y	**NOAA, FWS, NatureServe**. This indicator is available from a variety of sources with varying pros and cons of the datasets. SIRRA currently maintains a version of this indicator.
TES hotspot	N	**SIRRA**. "TES Hotspot" dataset.
Fish richness	N	No dataset available. This indicator has potential to be calculated from FWS and NatureServe databases.
Natural disaster risk	Y	**FEMA, USGS, NOAA**. CorpsMap also offers a great deal of weather data – especially concerning drought and flood risk based on current conditions. SIRRA currently maintains a version of this indicator.
Hurricane risk	N	**FEMA, USGS, NOAA**. SIRRA data calculations can be transferred to develop this indicator.
Flood risk	N	**FEMA, JAWRA**. SIRRA currently maintains a version of this indicator. SIRRA found national insurance maps to be an ideal data source, yet cumbersome. Alternative sources may be re-explored.
Transportation		
Critical waterway links	N	No dataset available. This indicator requires definition and calculation development.

Candidate Indicator	Data Exists in CorpsMap	Potential Data Sources
Proximity to interstate	Y	**U.S. Census Bureau**.
Proximity to railway	Y	**U.S. Census Bureau**.
USACE project or managed site		
CDF site locations	Y	The most extensive, centralized list of USACE managed sites is contained in the "Corps Project Notebook" on CorpsMap. More detailed or extensive datasets could likely be obtained or created through partnership with a target district.
CDF area (acres)	Y	
Types of CDF contamination	Y	
Contaminated CDF site locations	Y	
CDF percentage capacity reached	Y	
Flood management infrastructure site locations	Y	
Wetland/riparian site locations	Y	
Aquatic ecosystem restoration site locations	Y	
Aquatic Plant Control Program site locations	Y	
Vegetation management site locations	Y	
Hazardous/ FUSRAP waste site locations	Y	
Hydropower site locations	Y	**CorpsMap**. "Hydroelectric Dams" dataset.
Forest site locations	Y	**NLCD**. Landcover dataset.
Grassland site locations	Y	**NLCD**. Landcover dataset.
Recreation site locations	Y	**CorpsMap**. "Recreation Areas" dataset.
Agricultural outlease site locations	N	No dataset available. This indicator requires data aggregation.
Laws and incentives		
Energy legislation	N	No dataset available. These indicators require definition and calculation development. The energy data portals described in Chapter 2 of this report offer viable data sources.
Biofuel incentives	N	
Biofuel coalitions	N	
Economy		
Unemployment	N	**U.S. Census Bureau, Bureau of Labor Statistics**. SIRRA currently maintains a version of this indicator.
Agricultural economic sector condition	N	**U.S. Census Bureau, Bureau of Labor Statistics**. This indicator requires definition and calculation development.

4.2 Next steps

This effort went as far as identifying candidate indicators based solely on analysis of USACE business line suitability. A final SIRRA Biofuel Application requires further development, and the next steps are described below.

4.2.1 Indicator evaluation

Evaluation of the candidate indicator set provides validity. This step seeks input from literature, subject experts, and users to establish: conceptual relevance; overall usefulness; feasibility of data collection and maintenance; and exclusion and inclusion criteria for each indicator. The result will be a final set of indicators aligned with user needs and expectations.

4.2.2 Indicator development

Given a final set of indicators, development is the act of collecting the data and providing the measurement. Execution of this step involves specifying the data source, compiling the data, performing any calculations on the data that may be necessary to arrive at the indicator, and establishing metadata.

4.2.3 Indicator publication

The expectation is that the SIRRA Biofuels Application analysis indicators will be integrated into CorpsMap (or an alternative data portal), making it accessible to users. This step executes that integration, which includes development of a data maintenance schedule. Additionally, this step publishes reports and briefings documenting the process and use to stakeholders.

4.2.4 Analysis development

The SIRRA framework is a collection of indicators. Indices (a combination of indicators) are often more informative to decisions. SIRRA users are expected to sort and weight indicators based on their specific application. For common applications, SIRRA developers have defined and evaluated specific sorting and weighting process and published the results in the form of this report. This next step would establish those processes for specific applications and provide results to stakeholders.

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Abbreviations

Term	Spellout
AFDC	Alternative Fuels Data Center
AFVs	alternative fuel vehicles
CDF	confined disposal facility
CEERD	U.S. Army Corps of Engineers, Engineer Research and Development Center
CERL	Construction Engineering Research Laboratory
CW	Civil Works
DOE	U.S. Department of Energy
EIA	U.S. Energy Information Administration
EISA	Energy Independence and Security Act
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
FEMA	Federal Emergency Management Agency
FRM	flood risk management
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	fiscal year
GHG	greenhouse gas
GIS	geographic information system
HEVs	hybrid electric vehicles
HUC	hydrologic unit code
HUD	U.S. Department of Housing and Urban Development
INL	Idaho National Laboratory
IWR	Institute for Water Resources
KDF	Knowledge Discovery Framework
MTS	Marine Transportation System
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
P.L.	Public Law
RFS	Renewable Fuels Standards
RVO	renewable volume obligation
SIRRA	Sustainable Installations Regional Resource Assessment
SWWRP	System-Wide Water Resources Program

Term	Spellout
TES	threatened and endangered species
TR	technical report
U.S.	United States
URL	universal resource locator
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
WWW	World Wide Web

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
December 2014	Final Technical Report	

4. TITLE AND SUBTITLE
Biofuel Production: Considerations for USACE Civil Works Business Lines

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT
USACE IWR Global Change Sustainability

6. AUTHOR(S)
Natalie R. Myers, Dick L. Gebhart, and Matthew D. Hiett

5d. PROJECT NUMBER
403280

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
PO Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CERL TR-14-32

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Institute for Water Resources
7701 Telegraph Rd
Alexandria, VA 22315

10. SPONSOR/MONITOR'S ACRONYM(S)
HQUSACE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The 2007 Energy Independence and Security Act (EISA) has set goals for renewable fuels standards (RFS) that include the production of 36 billion gallons of biofuels by 2022, with 21 billion gallons from non-corn sources. To meet the congressionally mandated bioenergy goals, the evolving bioenergy industry in the United States must be efficient, reliable, and sustainable. To that end, industry leaders are encouraging stakeholder engagement. Because it manages large areas of land, the U.S. Army is gaining national appeal for providing cellulosic feedstock to an emerging biofuels industry. Although not currently engaged, the Army and its directorates are investigating how biofuel production might impact the future viability of their mission and operations. The indicator framework presented in this document characterizes regional aspects of biofuel production, which is intended to provide a heightened awareness of how biofuel production might address various long-term issues and threats to mission sustainment.

15. SUBJECT TERMS
biofuels, Energy Independence and Security Act (EISA), renewable fuels standards (RFS), U.S. Army

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
Unclassified	Unclassified	Unclassified	UU	56	